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EXAMINER
SUCH, MATTHEW W

ART UNIT	PAPER NUMBER
2891	

DATE MAILED: 12/16/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

OK

Office Action Summary	Application No.	Applicant(s)	
	10/708,978	BROWN ET AL.	
	Examiner	Art Unit	
	Matthew W. Such	2891	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *05 April 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☐ Claim(s) _____ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-30* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *05 April 2004* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *05 April 2004*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

Claim Rejections - 35 USC § 112

1. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

2. Claims 11 and 12 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 11 and 12 are stated as depending from themselves, respectively.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

4. Claims 1-2, 5-12, 16-18, 20-24, 27, and 29-30 are rejected under 35 U.S.C. 102(b) as being anticipated by Miyamoto (US 6,040,021).

5. Regarding claim 1, Miyamoto teaches a semiconductor device and a method of making the device with an interconnect structure by depositing a titanium layer (Col. 5, Lines 2-9) on an interconnect having one or more contact openings which expose open or more silicide regions (Col. 5, Line 18 and Col. 16). An in-situ (Col. 5, Lines 45-47 and Col. 18, Lines 51-59) plasma nitridation process (Col. 5, Lines 9-10) is subjected on the titanium layer, followed by an additional deposition of at least one layer of titanium nitride (Col. 5, Lines 10-13; Col. 17, Lines 40-42; Col. 18), and a deposition of tungsten (Col. 1, Lines 35-59 and Col. 17, Lines 43-45).

6. Regarding claims 2 and 5, Miyamoto teaches the silicide regions are comprised of silicon and titanium (Col. 5, Line 18 and Col. 18).

7. Regarding claim 6, Miyamoto teaches cleaning the silicide interconnect structure prior to titanium deposition (Col. 16, Lines 29-33 and Col. 18, Lines 10-13).

8. Regarding claims 7 and 8, Miyamoto teaches using a metal films can be formed on substrates by sputtering (Col. 5, Line 3) and that the titanium layer is several nanometers thick (Col. 7, Lines 19-20).

9. Regarding claim 9, Miyamoto teaches all free titanium is converted to titanium nitride (Col. 7, Lines 19-20) during an in-situ plasma process in a nitrogen and hydrogen gas environment (Col. 3, Lines 14-18 and Col. 17, Lines 21-38). Furthermore, Miyamoto teaches that layers of titanium 20 nm thick can be deposited without complete nitridation of the free titanium, which leaves a two-layer structure of titanium and titanium nitride (Col. 17, Lines 59-63).

10. Regarding claims 10-12, in so far as definite, Miyamoto teaches the method of claim 1 where the in-situ plasma nitridation process is performed at a temperature of 500°C or less (Col. 3, Lines 14-18).

11. Regarding claims 16-18, Miyamoto teaches that chemical vapor deposition can be used to deposit at least one titanium nitride layers using a titanium-containing precursor of TDMAT, TDEAT, and titanium tetrachloride (Col. 1, Lines 45-55). Furthermore, Miyamoto teaches that prior art uses a nitrogen-containing precursor of ammonia (Col. 2, Lines 54-59).

12. Regarding claim 20, Miyamoto teaches that at least two layers of titanium nitride are deposited on an in-situ plasma treated titanium layer (Col 18, Lines 65-67).

13. Regarding claims 21 and 22, Miyamoto teaches a titanium-deposited layer that has been subjected to an in-situ gas plasma nitridation process, which by applicant's definite comprises a low thermal budget middle of the line (MOL) liner (Col. 5, Lines 2-13; Col. 17, Lines 40-42; Col. 18), where the MOL liner has a thickness several nanometers, or about 25Å to 250Å (Col. 7, Lines 19-20).

14. Regarding claim 23, Miyamoto teaches a semiconductor device having a silicide contact comprising an interconnect structure with one or more contact openings (Col. 5, Line 18 and Col. 16), a low thermal budget MOL liner formed above a silicide contact (Col. 5, Lines 2-13; Col. 17, Lines 40-42; Col. 18) and one or more titanium nitride layers on the low thermal budget MOL liner (Col 18, Lines 65-67).

15. Regarding claim 24, Miyamoto teaches that silicide regions are comprised of silicon and titanium (Col. 5, Line 18 and Col. 18).

16. Regarding claim 27, Miyamoto teaches that the titanium layer is several nanometers thick, or about 25Å to about 250Å (Col. 7, Lines 19-20).

17. Regarding claims 29 and 30, Miyamoto who teaches that the device is subjected to a bulk tungsten-filling step that may be performed by a chemical vapor deposition process (Col. 1, Lines 35-39).

Claim Rejections - 35 USC § 103

18. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

19. Claims 3-4 and 25-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Miyamoto in view of Li (US 6,573,571).

Miyamoto teaches a semiconductor device of claim 23 and method of forming the device of claim 1 having an interconnect structure with one or more contact openings having exposed metal silicide regions (Col. 5, Lines 14-18) and also discloses the method by which a metal silicide can be formed. As an example, Miyamoto teaches a method for forming a metal silicide region where the metal is titanium (Col. 16), but does not teach specific examples for other metals that may be used in a metal silicide region.

Li teaches a variety of other conventional metals, including nickel and cobalt, which may be used in forming metal silicide regions on interconnect structures (Col. 8, Lines 18-49) where the metals react with silicon at 600°C or less, making each attractive alternative metals for forming a silicide region. Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to use either cobalt silicide or nickel silicide regions in place of titanium silicide in an interconnect structure because Li teaches silicides of Ti, Ni and Co were known functional equivalents.

20. Claims 13-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Miyamoto in view of Leusink (US 6,274,496).

Miyamoto teaches a method of forming a semiconductor device interconnect structure containing titanium nitride produced by an in-situ plasma nitridation process as

described in claim 1 where the plasma temperature is 500°C or less in order to form a layer of any desired thickness, but does not specifically detail the reaction time required to form for any desired thickness.

Leusink teaches an in-situ plasma process for the nitridation of titanium layers between 20Å and 2000Å thick, depending on the desired application, and that the nitridation processing time can vary from about 1-100 seconds, with 30-50 seconds being preferred (Col. 6, Lines 60-63). Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to use a processing time anywhere between 5-60 seconds, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or working ranges involves only routine skill in the art. In re Aller, 105 USPQ 233.

21. Claims 19 and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Miyamoto in view of Selsley (US 6,316,353).

Miyamoto teaches a semiconductor device of claim 23 and method of forming the device of claim 1 having an interconnect structure with one or more contact openings having titanium nitride layers, where a titanium film of several nanometers thickness can be converted to titanium nitride. Miyamoto also teaches that the total titanium nitride layer thickness can be adjusted to any desired level by a plurality of repeated titanium nitride deposition reactions (Col. 5, Lines 9-13). However, Miyamoto does not teach the claimed specific titanium nitride film thickness range of 15Å to 100Å, only that subjecting a titanium deposition layer of 20nm (or 200Å) to an in-situ plasma nitridization results in

a double layer structure of titanium film covered with titanium nitride film (C17, Lines 59-63), which provides an upper limit for a single deposition of titanium nitride film.

Selsley also teaches semiconductor device and method of forming the device of claim 1 having an interconnect structure with one or more contact openings having titanium nitride layers, where the first titanium nitride layer is 5Å to 50Å (Col. 4, Lines 46-48), and the second titanium nitride layer is 100Å to 200Å where all of the free titanium is converted to titanium nitride (Col. 5, Lines 19-23). Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have the titanium nitride layers between 15Å and 100Å to ensure uniform nitridation of the deposited titanium during an in-situ plasma process, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or working ranges involves only routine skill in the art. In re Aller, 105 USPQ 233.

Conclusion

22. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

US 5,654,235 to Matsumoto, US 6,080,665 to Chen, US 6,093,645 to Ameen, US 6,180,522 to Hong, US 6,259,142 to Dawson, US 6,537,621 to Kobayashi, US 6,573,181 to Srinivas, US 6,635,569 to Ameen, US 6,649,518 to Selsley, US 6,661,057 to Dawson, and US 6,780,764 to Morita teach various methods for forming interconnect structures by nitridization of titanium layers prior to metal interconnect formation.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew W. Such whose telephone number is (571) 272-8895. The examiner can normally be reached on Monday - Friday 8AM-5PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Bradley W. Baumeister can be reached on (571)272-1722. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew W. Such
Examiner
ART Unit 2891

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